Interference in Exclusive Vector Meson Production in Heavy Ion Collisions

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In relativistic heavy ion collisions, vector mesons are copiously produced via photon-Pomeron fusion[1]. Because the photon has a long range and the Pomeron a short range, production occurs in or near the Pomeron emitting nucleus ('target'). Since either nucleus can emit the Pomeron, meson production occurs at two sources. Because of the kinematics, it is impossible to tell which nucleus is the photon source and which is the target, so the two emission amplitudes add. The situation is similar to a two-slit interferometer, albeit with unstable particles. The nuclei travel in opposite directions, so parity inversion switches the emitter and target. Because vector mesons are negative parity, the two emission amplitudes have opposite signs. If the meson wavelength is larger than the impact parameter b, the two sources interfere destructively. This happens when the meson perpendicular momentum, $p_\perp \ll \hbar/b$. At midrapidity at $p_\perp = 0$, the emission $dN/dp_\perp^2$ is zero.

Since b is not observable, the $p_\perp$ spectrum may be calculated as a function of rapidity by integrating the production cross section over impact parameter. Fig. 1 shows some resulting $p_\perp$ spectra[2].

Because vector meson lifetimes are so short, they decay before the travel the distance b. So, the original mesons cannot interfere with each other. However, the decay products do overlap and interfere. Since the decay product amplitudes from one source are well separated by the time they overlap with amplitudes from the other source, the complete wave function must be non-local. For a 2-particle decay, the wave function has the form $\exp(ik_1 \cdot x_1)\exp(ik_2 \cdot x_2) - \exp(ik_1 \cdot x_2)\exp(ik_2 \cdot x_1)$ where x_1 and x_2 are the production points and k_1 and k_2 the decay product momenta.

We expect to measure this interference in 2000 with STAR[3].

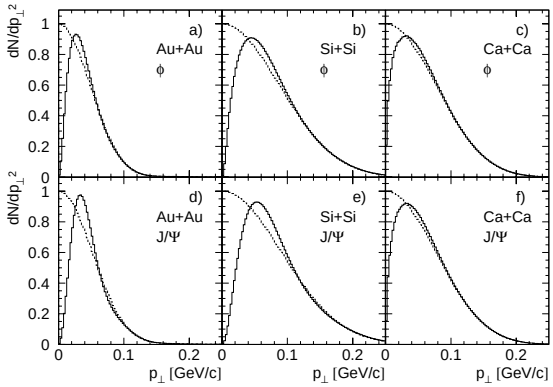

Figure 1: Perpendicular Momentum spectrum both with and without interference, for (a,d) gold beams at RHIC, (b,e) silicon beams at RHIC and (c,f) calcium beams at the LHC. The solid histograms include interference, while the dotted ones do not.

References

[1] S. Klein and J. Nystrand, Phys. Rev. **C60**, 014903 (1999).

[2] S. Klein and J. Nystrand, "Interference in Exclusive Vector Meson Production in Heavy Ion Collisions," hep-ph/9909237, to appear in Phys. Rev. Lett..

[3] J. Nystrand and S. Klein, "Two-Photon Physics in Nucleus-Nucleus Collisions at RHIC", nucl-ex/9811007, Nov., 1998, in Proc. Workshop on Photon Interactions and the Photon Structure, Lund, Sweden, Sept., 1998.